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Compte rendu de la réunion du sous-comité du saumon du CEESP 13-15 mai 2003

May 13-15, 2003
Nanaimo, B.C.

R. Tanasichuk
Salmon Subcommittee Chair

Fisheries and Oceans Canada
Pacific Scientific Advice Review Committee
Pacific Biological Station
Nanaimo, British Columbia V9T 6N7

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PACIFIC SCIENTIFIC ADVICE REVIEW COMMITTEE (PSARC)
SALMON SUBCOMMITTEE MEETING

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SUMMARY

The Pacific Scientific Advice Review Committee (PSARC) Salmon Subcommittee met May 13-15, 2003 at the Pacific Biological Station, Nanaimo, B.C. to review seven Working Papers.

Working Paper S2003-07: Trends in abundance for Northern BC chum salmon

This Working Paper describes trends in abundance for North Coast (Statistical Areas 1-6) wild chum salmon. Escapement trends and a time series of escapement indices were presented. Results suggested that abundance of Queen Charlotte Islands (QCI) chum has been stable over time but is low in Area 1. Abundance of North Coast chum has been declining over time. The Subcommittee recommended that the conservative management approach in place for Areas 2E and 2W be followed and a cautious approach with respect to Area 1 chum. A reduction in fishing is warranted for North Coast (Areas 3-6) chum.

The Subcommittee accepted the paper with revisions. These revisions included evaluating the retrospective performance of different forecasting models as well as various indices of abundance.

Working Paper S2003-08: Assembly of standardized estimates of juvenile and adult sockeye salmon (*Onchorynchus nerka*) abundance associated with the 1976-2001 brood years in Henderson Lake and Clemens Creek, British Columbia

This paper is the first of a series which will collectively describe the stock status of Henderson lake sockeye. Results presented indicated that fertilization increases the carrying capacity of Henderson Lake by threefold. There appears to be an inverse relationship between abundance and smolt weight. In addition, there appears to be a direct relationship between numbers of spawners and subsequent fry.

The Subcommittee recommended that effort be directed to complete the remainder of the reports (climate/habitat effect, mixed-stock fishery concerns, hatchery/wild interactions) which assess the stock status of Henderson Lake sockeye. It also recommended that effort be put into using a Bayesian approach to provide a composite estimate of escapement because this is crucial to provide estimates of exploitation. The Subcommittee noted that Henderson Lake sockeye are being taken in the Barkley Sound fishery and that area and time restrictions are in place to minimise impacts.

Working Paper S2003-09: Stock status and lake-based production relationships for wild Skeena River sockeye salmon

This paper described the stock status of wild Skeena River sockeye and introduced a simulation model which predicted escapements to lakes under different fishing

regimes. Status was determined by comparing carrying capacity estimated from a photosynthetic rate model with adult escapement data. The Authors also present a method for determining stock and recruitment relationships between smolt biomass and spawning escapement using the PR-model output.

The Subcommittee accepted the empirical description of stock status and noted that Bulkley and Maxan were lakes of concern. It recommended habitat assessments and lake surveys for these systems. It also recommended that fishing plans should recognise the depressed status of many of the small stocks and the need to preserve spawners. The stock-recruit relationships and simulation modeling were considered to be in a preliminary form and will be developed in the future. Therefore, they will not be included in the revised paper.

Working Paper S2003-10: Models to adjust spawning escapement targets for Fraser River sockeye salmon (*Oncorhynchus nerka*) to compensate for the influence of environmental conditions on migration success

The goal of this paper was to test whether interannual variations in Fraser River temperature and discharge explained the reduction in abundance estimates at Mission and spawning escapements. If so, a prediction of in-river mortality could be made and consequently could be used to provide an in-season adjustment to fishing so that the likelihood of attaining spawning escapement targets would be maximised. Results indicated that there were run-timing group-specific environmental conditions that explained the differences but the improvements were not quantified.

The Subcommittee accepted the paper with revisions and noted that this was a work in progress. It recommended that uncertainty should be addressed and that forecasts be expressed in the context of probability distributions. The Authors indicated that qualitative forecasts have been provided to the Fraser Panel beginning in 2001.

Working Paper S2003-11: Inseason forecasting of North Coast coho salmon marine survival: A decision-analytic method and retrospective analysis

This paper used historic coded-wire tag releases and marine survival estimates for indicator streams, and upper Skeena tag recoveries and catch and effort data from Southeast Alaska troll fisheries to develop a model which provides in-season forecasts of North Coast coho marine survival. The estimation procedure performed well and made the correct prediction in 19 of 20 instances.

The Subcommittee complimented the Authors on the excellent work which has general applicability. The decision-analytic approach provides incentive to consult with user groups to establish the cost of errors in decision-making.

Working Paper S2003-12: Stock status of wild chum salmon returning to British Columbia's Central Coast and Johnstone and Georgia Straits (excluding the Fraser River)

This paper describes the status of chum salmon returning to the Central Coast and Non-Fraser Inner Study Area. Measures of stock status included stock size, analysis of spawning escapement and recruit per spawner trends, and categories of stock size based on reference points.

The Subcommittee accepted the paper with revisions. It recommended that stock status be considered in the context of escapement indices because of analytical problems associated with attempting to estimate missing data and then develop a stock status indicator based on stock-recruit analysis.

Working Paper S2003-13: Review of 2002 chinook returns to the west coast Vancouver Island, forecast of the 2003 returns to the Stamp River/ Robertson Creek hatchery indicator stock, and outlook for other WCVI chinook stocks

The Subcommittee accepted the Working Paper and forecasts. It is anticipated that the return of Stamp Falls/Robertson Creek Hatchery chinook to the terminal area of Barkley Sound (86,000) will be similar to the 2002 return. Unlike recent years, all age-classes of adults will be represented, including the age-5 component which is mostly female. The number of females predicted in the terminal run is 46,000 which would contribute a potential deposition of 210 million eggs, four times the current egg deposition goal. Based on the forecasted return for Stamp Falls/Robertson Creek Hatchery chinook, most wild populations are expected to have more than 100 females, and egg deposition should improve because of an increase in the sex ratio in favour of females. Populations in Kyuquot and Clayoquot Sounds remain depressed.

The Subcommittee considered the fishery advice to be consistent with apparent stock trends. The Subcommittee recommended that forecasts for WCVI chinook be presented based on probability distributions, as is the case for other forecasts. In addition, research should be conducted to evaluate the apparent declines in Kyuquot and Clayoquot chinook abundance, and if verified, extended to determine the causes of the reduction.

SOMMAIRE

Le sous-comité du saumon du Comité d'examen des évaluations scientifiques du Pacifique (CEESP) s'est réuni du 13 au 15 mai 2003 à la Station biologique du Pacifique, située à Nanaimo, en Colombie-Britannique, pour passer en revue sept documents de travail.

Document de travail S2003-07 : Tendances de l'abondance du saumon kéta sur la côte nord de la Colombie-Britannique

Ce document de travail décrit les tendances de l'abondance du saumon kéta sauvage sur la côte nord de la Colombie-Britannique (zones statistiques 1-6). Les tendances des échappées et une série chronologique d'indices d'échappées sont aussi présentées. Les résultats suggèrent que l'abondance du kéta sauvage dans le secteur des îles de la Reine-Charlotte (IRC) est demeurée stable au fil du temps mais qu'elle est faible dans la zone 1, tandis qu'elle a diminué au fil du temps sur la côte nord. Le sous-comité recommande que l'on suive l'approche de gestion prudente mise en place pour les zones 2E et 2W et que l'on adopte une approche de prudence pour le kéta de la zone 1. En outre, une réduction de la pêche du kéta sur la côte nord (zones 3-6) est justifiée.

Le sous-comité accepte le document sous réserve de révisions incluant l'évaluation de la performance rétrospective de divers modèles prévisionnels et de divers indices d'abondance.

Document de travail S2003-08 : Rassemblement d'estimations normalisées de l'abondance du saumon rouge (*Onchorynchus nerka*) juvénile et adulte issu du lac Henderson et du ruisseau Clemens, en Colombie-Britannique, entre 1976 et 2001

Ce document est le premier d'une série visant à décrire dans l'ensemble l'état du stock de saumon rouge du lac Henderson. Les résultats présentés indiquent que la fertilisation mène au triplement de la capacité de charge du lac. Il semble exister une relation inverse entre l'abondance et le poids des smolts, ainsi qu'une relation directe entre le nombre de reproducteurs et le nombre d'alevins produits.

Le sous-comité recommande que l'on complète les autres rapports d'évaluation de l'état du stock de saumon rouge du lac Henderson (incidences climatiques sur l'habitat, préoccupations soulevées par la pêche de stocks mélangés, interactions entre le saumon sauvage et le saumon d'élevage). Il recommande aussi que l'on utilise des méthodes bayésiennes pour obtenir une estimation agrégative de l'échappée, essentielle pour obtenir des estimations du taux d'exploitation. Le sous-comité note que le saumon rouge du lac Henderson est capturé dans les pêcheries de la baie Barkley et que des restrictions visant les zones et les périodes de pêche sont en place afin de réduire les incidences de la pêche au minimum.

Document de travail S2003-09 : État du stock de saumon rouge sauvage de la rivière Skeena et relations avec la production lacustre

Ce document décrit l'état du stock de saumon rouge sauvage de la rivière Skeena et présente un modèle de simulation pour prédire les échappées dans les lacs selon différents régimes de pêche. Une comparaison de la capacité de charge, estimée à l'aide d'un modèle du rendement photosynthétique et des échappées d'adultes, a

servi à déterminer l'état du stock. Les auteurs présentent aussi une méthode pour établir les relations stock-recrutement entre la biomasse de smolts et l'échappée à l'aide de la sortie du modèle du rendement photosynthétique.

Le sous-comité accepte la description empirique de l'état du stock et note que les lacs Bulkley et Maxan sont préoccupants. Il recommande que des évaluations de l'habitat et des relevés de ces lacs soient effectuées. Il recommande en outre que les plans de pêche tiennent compte de l'état affaibli de nombreux des petits stocks et du besoin de protéger les géniteurs. Comme les relations stock-recrutement et le modèle de simulation sont considérés comme préliminaires et qu'ils doivent être peaufinés, ils ne seront pas inclus dans le document révisé.

Document de travail S2003-10 : Modèles d'ajustement des cibles d'échappées du saumon rouge (*Oncorhynchus nerka*) du Fraser pour compenser l'influence des conditions environnementales sur le succès de la migration

L'objet de ce document était d'établir si les variations interannuelles de la température et du débit du Fraser permettaient d'expliquer la baisse de l'abondance estimée à Mission et celle des échappées de géniteurs. Si cela est le cas, on pourrait prédire le taux de mortalité en rivière, ce qui permettrait de rajuster les niveaux de capture pendant la saison de pêche de sorte à maximiser la probabilité que les cibles d'échappées soient atteintes. Les résultats révèlent l'existence de conditions environnementales spécifiques à des groupes de remonte qui expliquent ces différences, mais les améliorations n'ont pas été quantifiées.

Le sous-comité accepte le document sous réserve de révisions et note que les travaux se poursuivent. Il recommande que l'incertitude entourant les prévisions soit abordée et que celles-ci soient exprimées en termes de fonctions de distribution de probabilités. Les auteurs ont indiqué que des prévisions qualitatives ont été présentées au Conseil du fleuve Fraser depuis 2001.

Document de travail S2003-11 : Prévision en saison de la survie en mer du saumon coho de la côte nord : méthode d'analyse des décisions et analyse rétrospective

Ce document présente un modèle reposant sur des données historiques des micromarques magnétisées codées récupérées et des estimations de la survie en mer de cohos issus de cours d'eau indicateurs, sur des données provenant des micromarques récupérées dans la Haute-Skeena ainsi que sur des données de prises et d'effort relatives aux pêches aux lignes traînantes dans le sud-est de l'Alaska, afin de faire des prévisions en saison de la survie en mer du saumon coho de la côte nord. Cette procédure d'estimation a donné de bons résultats, la prévision étant correcte 19 fois sur 20.

Le sous-comité félicite les auteurs pour leur excellent travail, d'application générale. La méthode d'analyse des décisions encourage à consulter les groupes d'utilisateurs pour établir les coûts des erreurs dans la prise de décision.

Document de travail S2003-12 : État du stock de saumon kéta sauvage revenant à la côte centrale de la Colombie-Britannique et dans les détroits de Johnstone et de Georgia (à l'exception du Fraser)

Ce document décrit l'état du stock de saumon kéta revenant à la côte centrale et à la zone d'étude côtière, à l'exception du Fraser. Les mesures de l'état du stock incluent ses effectifs, une analyse de l'échappée, les tendances du nombre de recrues par géniteur et des niveaux des effectifs du stock reposant sur des points de référence.

Le sous-comité accepte le document sous réserve de révisions. Il recommande que l'état du stock soit considéré dans le contexte des indices d'échappées à cause des problèmes d'analyse qui surviennent lorsqu'on tente d'estimer les données manquantes puis de développer un indicateur de l'état d'un stock d'après une analyse du recrutement au stock.

Document de travail S2003-13 : Examen des remontes de saumon quinnat de 2002 sur la côte ouest de l'île de Vancouver, prévision des remontes de 2003 du stock d'écloserie indicateur de la rivière Stamp et du ruisseau Robertson et perspectives pour d'autres stocks de quinnat de la COIV

Le sous-comité accepte le document de travail et les prévisions. On prévoit que la remonte de quinnat d'élevage issu de la rivière Stamp et du ruisseau Robertson dans l'estuaire de la baie Barkley (86 000) sera semblable à 2002. À la différence des dernières années, toutes les classes d'âge d'adultes seront représentées, y compris l'âge 5, composé principalement de femelles. On prévoit que le nombre de femelles dans la remonte terminale atteindra 46 000 individus, qui pourraient pondre 210 millions d'œufs, soit quatre fois la cible de ponte actuelle. D'après la remonte prévue de quinnat d'élevage issu de la rivière Stamp et du ruisseau Robertson, on s'attend à ce que la plupart des populations sauvages incluent plus de 100 femelles; la proportion des sexes favorisant les femelles, la ponte devrait donc être meilleure. Les populations des baies Kyuquot et Clayoquot sont encore affaiblies.

Le sous-comité considère que les avis sur les pêches correspondent aux tendances apparentes du stock. Il recommande que les prévisions présentées pour le quinnat de la COIV reposent sur des fonctions de distribution de probabilités, comme cela est le cas des autres prévisions. En outre, des recherches devraient être menées en vue d'évaluer le déclin apparent de l'abondance du quinnat dans les baies Kyuquot et Clayoquot et, si cela est le cas, poursuivies afin de déterminer les causes de cette baisse.

INTRODUCTION

The PSARC Salmon Subcommittee met May 13-15, 2003, at Pacific Biological Station in Nanaimo, British Columbia. External participants from the Pacific Fisheries Resource Conservation Council, Nuu Chah Nulth Tribal Council, Sport Fishing Advisory Board, Pacific Salmon Harvesters Society, Kwakiutl Territories Fisheries Commission, Fishing Vessel Owners' Association, and the BC Sport Fishing Association attended the meeting. A consultant and a representative from the Area G, Troll Association also attended the meeting as observers. The Subcommittee Chair, R. Tanasichuk, opened the meeting by welcoming the participants. During the introductory remarks, the objectives of the meeting were reviewed, and the Subcommittee accepted the meeting agenda.

The Subcommittee reviewed seven Working Papers. Summaries of the Working Papers are in Appendix 1. The meeting agenda appears as Appendix 2. A list of meeting participants, observers and reviewers is included as Appendix 3.

DETAILED COMMENTS FROM THE REVIEW

S2003-07: Trends in abundance for Northern BC chum salmon

B. Spilsted **Accepted subject to revisions**

Subcommittee Discussion

Data, forecasting methods and forecast performance

This working paper describes trends in abundance and 2003 forecasts for North Coast (Statistical Areas 1-6) wild chum salmon. Escapement estimates are based on visual surveys of streams. An annual time series of escapement indices for each of the stream aggregates was developed as the mean proportion of maximum observed escapement over streams within an aggregate. The index, referred to as P_{max}, was used in previous forecast models reviewed by PSARC. Indices were developed using information for streams which had not received any enhancement and had at least 10 years of data for 1950 – 2002. Both Reviewers were highly complimentary of the paper. One reviewer suggested that data limitations be discussed more fully and questioned whether returns to enhanced streams could be used as indicators of wild stock status. The Author indicated that inadequate sampling precludes this.

Chum escapements were forecasted using the 3, 5 and all years (n-year) time series models which have been approved by PSARC. Forecasts were made for the total escapement (all streams) and an index escapement aggregate for each area. The Subcommittee expressed concern regarding the potential non-random selection of streams to be surveyed as survey effort declined. The Author felt that there was potential bias because effort focussed on larger streams which would ultimately

support fisheries. The Subcommittee suggested that a subset of streams which were consistently sampled over the time series be used to see if trends are similar to that for the complete dataset. These results may have implications for the current forecasting models. In addition, it would be useful to compare P_{max} and abundance time series for streams with data of higher quality.

The Subcommittee noted that no retrospective analysis of forecast performance was presented. In addition the 3-year average model was considered to be inappropriate for chum because the average age-at-maturity is age-4. Retrospective analyses of the 5- and n-year forecasting models was requested for the revision. The Subcommittee requested that an historical description of the chum fisheries be included in the revision. A table describing the source of the DFO target escapements should also be included.

Stock Status

Trends in abundance were described in the context of escapement goals. The Author noted that escapement goals reflect a manager's best estimate of the desired escapement for each stream, and that there is no technical or biological basis for the estimates. One reviewer noted that escapement goals were rarely met and questioned whether they were biologically reasonable. The index of abundance for QCI chum suggests that abundance for 1950-1952 was much higher than recent years. Abundance from the late 1960s to the present has been stable, except for Area 2E where there has been a decline over time. It is unclear whether the declines in the early 1950s are real or whether they are due to a change in staff or methodology. The index for the North Coast suggests a general trend of declining abundance throughout the entire time series. In 1999, the spawning escapement indices for Areas 3 and 5 were some of the lowest on record and was in the lowest on record for Area 6. The status of aggregates from Statistical Areas 3, 5 and 6 is classified as Depressed (Appendix 1 in the Working Paper). Streams with average escapements less than 5,000 fish show a decrease in abundance over time whereas streams with average escapements greater than 5,000 show no trend in abundance. One reviewer felt that the conclusions regarding stock status were supported by the data and analyses. The Subcommittee suggested that stock status should be portrayed relative to the long-term average.

Total stock estimates were not made because of uncertainty regarding stock composition of the catch and the proportion of the catch which would have been wild chum.

The 2003 forecast

The recommended forecasts in the Working Paper are based on the five-year running average model (Appendix 1 in the Working Paper). Forecast escapements for all aggregates are below the escapement goal. Although outside the scope of the Working Paper, the Subcommittee noted that a review of escapement goals is

warranted. The Subcommittee discussed the relevance of the current conservative management approach for terminal net fisheries. One reviewer thought the management approach is appropriate for stable systems such as QCI chum but questioned its use on systems showing declining trends and suggested a reduced harvest is more appropriate considering the decline in the abundance of those stocks.

Subcommittee Conclusions

Escapement trends show long-term declines for some North Coast chum with recent poor escapements. For those stocks, a reduction in harvest is warranted. The Subcommittee concluded that the current conservative management approach of inlet-specific net fisheries on the identified escapement surplus in QCI is appropriate. It also supports the cautious approach for Area 1 chum.

The Subcommittee accepted the paper with revisions. Revisions should include i) a retrospective analysis of forecast performance, ii) a correlation analysis of abundances among stocks to investigate regional patterns; this should include Alaskan data, and iii) an assessment of the number of streams within an aggregate required for a reliable estimate of P_{max}

Subcommittee Recommendations

The Subcommittee recommended continuing the current management approach for Areas 2E and 2W and caution for Areas 1 and 3 through 6.

The Subcommittee recommended that a PSARC paper be prepared which evaluates P_{max} as an index of escapements and includes investigating alternative approaches for standardizing escapements. The paper should also include a sensitivity analysis to determine the minimum number of streams and years of data needed to derive a stable estimate of P_{max} index.

S2003-08: Assembly of standardized estimates of juvenile and adult sockeye salmon (*Oncorhynchus nerka*) abundance associated with the 1976-2002 brood years in Henderson Lake and Clemens Creek, British Columbia

K. Hyatt, D.P. Rankin, P.J. Tschaplinski, and I. Miki **Accepted with revisions**

Subcommittee Discussion

Data and Methods

The objectives of this working paper were to i) develop and document standardized estimates of juvenile and adult sockeye abundance, ii) use the estimates to assess the effect of lake fertilization, iii) identify other factors affecting sockeye production,

and iv) provide advice for additional assessment work to address the status of Henderson Lake sockeye within the Barkley Sound sockeye stock aggregate. One reviewer concluded that the paper provided only a limited assessment of the effects of lake fertilisation on sockeye production. The Authors noted that there is a considerable amount of data (eg. habitat status) which was not included in the report. The Uchucklesaht Tribe has been collecting information which will be incorporated into future reports. In addition, there are test fishery samples which could provide information on stock structure (DNA, Strontium marks of Henderson Lake hatchery smolts) which have not been analysed yet. The Subcommittee noted that Henderson Lake sockeye are being taken in the Barkley Sound fishery and that area and time restrictions are in place to minimize impacts. There is no information on the relative impacts of fishing on wild and hatchery Henderson Lake sockeye.

Acoustic and trawl surveys were used to provide estimates of the juvenile sockeye and other limnetic fish. Estimates of juvenile sockeye abundance are based on estimating fish abundance in the hydro-acoustically assessed stratum, fish abundance in non-insonafiable stratum and species/developmental stage composition based on the laboratory sampling of subsamples of the catch. The strata abundance estimates are then summed up to produce an estimate of the total fish species abundance in the lake. In addition, samples of sockeye smolts are collected annually during their migration through the Henderson River to monitor age and size composition. Spawner escapements surveys (visual counts) at Henderson Lake and Clemens Creek have been conducted annually and between 1980 and 2001. One reviewer suggested that observer efficiencies should be used to correct counts. The Authors felt that observer efficiency estimates would not be defensible. The reviewer also suggested that the accuracy of the index based on peak counts be evaluated by comparing the index with estimates made using the Area-under-the-Curve calculation. This is the current method of choice and the reviewer pointed out that there appears to be adequate data to make this calculation. The Authors felt that the variability in Survey Life was great enough that there would be no benefit to this approach. The other reviewer also questioned why Area-under-the-Curve estimates were not made. The Authors indicated that escapement estimates on Clemens Creek vary substantially among survey types; therefore a consistent method of escapement estimation should be used. The Subcommittee noted that ultimately total counts will have to be done to estimate exploitation rates. In addition, one reviewer was concerned that the procedures for determining trawl capture efficiency are not described and therefore could not be evaluated. The Authors noted that these procedures are described in PSARC Working Paper S2000-21.

Results

Historical escapement and catch estimates suggest that the long-term average return of Henderson Lake sockeye is between 40 and 60 thousand fish. Smolts originating from years of the fertilization of Henderson Lake were significantly larger. In addition, size is inversely related to abundance of limnetic fish or sockeye fry. Differences in the limnetic fish biomass suggest that fertilization increases the

carrying capacity of Henderson Lake by threefold. One reviewer stated that this conclusion was tenuous because there were data for only three untreated years. The Authors responded that fish production estimates are precise enough and indicate that the differences are real. Peak spawner abundances in Clemens Creek varied substantially over 1981-2001 ranging from less than 5,000 (1986, 1987, 1995, 1999, 2001) to at least 119,000 in 1993 (Fig. 1.). Annual escapement counts are considered to be biased low because they do not include estimates of lake spawners nor account for the appreciable turnover of sockeye spawner that may occur weekly. The Authors concluded that peak counts provide an index of relative abundance. Results for the years from 1977 to 1993 indicate a linear relationship between juvenile sockeye abundance and spawner abundance. Egg-to-fry survival appears to have declined dramatically between 1976 and 1985 and was suppressed and constant between 1986 and 1996. Survival has increased dramatically since 1996. The apparent increase in egg-to-fry survival in 1999, 2000 and 2001 is confounded by hatchery production. There is currently no information on the proportion of fry production which is hatchery or wild. One reviewer suggested that the possible effects of fertilization on egg-to-fall fry survival be discussed more fully in revisions of the Working Paper. The reviewer questioned why survival apparently declined with the onset of fertilisation and then increased with the first untreated brood year. In addition, the reviewer was concerned about the conclusions drawn from a graph in the Working Paper (Fig. 10) which shows a plot of number of fry versus number of spawners. It may be possible that the apparent relationship for wild and hatchery fry may be confounded by lower fry quality during the early years of hatchery operation. The Authors found that the years of low fry abundance were not the early years of hatchery operation.

Subcommittee Conclusions

The paper was accepted with revisions. The Subcommittee noted this is one of a series of papers which will collectively assess the status of Henderson Lake sockeye.

Subcommittee Recommendations

The Subcommittee recommended that concerted effort should be made to complete the remainder of the reports (climate/habitat effect, mixed-stock fishery concerns, hatchery/wild interactions) which deal with the stock status of Henderson Lake sockeye.

The Subcommittee recommended that the use of probability distributions of residence time and other observations be used with Area-Under-The-Curve and mark recapture estimates in a Bayesian approach, to provide a composite estimate of escapement.

S2003-09: Stock status and lake-based production relationships for wild Skeena River sockeye salmon

S. Cox-Rogers, J. M. B. Hume, and K. S. Shortreed **Accepted with Revisions**

Subcommittee Discussion

Data and methods

This paper describes the stock status for wild Skeena River sockeye based on freshwater production in nursery lakes. Nursery lake-specific catch and escapement data for wild Skeena sockeye were considered inadequate for developing adult production relationships or to assess stock status precisely. Stock status was described based on a photosynthetic rate (PR) model which estimated the carrying capacity of nursery lakes and available adult escapement data. The Authors also present a method for determining stock and recruitment relationships between smolt biomass and spawning escapement using the PR-model output. A simulation model was subsequently developed which predicted escapements to Skeena nursery lakes under different fishing regimes.

Catch and escapement data for Skeena River sockeye from 1951-2002 and North Coast sockeye tagging studies were used to re-construct catches by stock in mixed-stock fisheries in Alaska and northern B.C. Limnological and limnetic data were from databases maintained by the DFO Lake Research Unit.

The PR model is derived from an Alaskan model which predicts optimum escapement, optimum spring fry recruitment, and maximum smolt output from euphotic zone volume. This model was modified for Skeena nursery lakes to consider sockeye fry competitors and the discrepancy between observed smolt size and that considered by the model (4.5 g). The PR model was used to provide estimates of stock (adult escapement) and recruitment (smolt biomass) for lakes where no stock-recruit data exists.

The fishery simulation model consisted of a production or stock dynamic module and a fishery-harvesting module to predicted escapement trends for each nursery lake. The production module was based on the PR-derived stock-recruitment (S-R) relationships. The harvest module considered American and Canadian commercial fisheries, and in-river and terminal Food, Social and Ceremonial and Excess Surplus of Spawning Requirement (ESSR) fisheries. It is based on the model currently used to manage the Area 3/4/5 fishery.

Stock status was described using available adult catch and escapement records, and juvenile densities expressed as a proportion of maximum carrying capacity. Only 17 of the 29 Skeena nursery lakes have been surveyed to date. The Authors interpolated lake trophic status and juvenile densities for the lakes with no data.

One reviewer thought the technical approach was reasonable but stated that parts of the paper and aspects of the analysis were unclear. The reviewer questioned the validity of some of the assumptions. The simulation model ignores correlation structure in the harvest rate or S-R parameter values which could affect the results. The reviewer concluded that the methods were adequate to support the qualitative conclusions. The Authors agreed to examine autocorrelations in S-R parameters. They will also re-estimate the variance of the estimate of PR_{Mean} and incorporate a table showing what adjustments were made to the PR model and how outputs are affected. The Authors noted that the time series of exploitation rates in some lakes are being collected and can be tested against model estimates.

Another reviewer complimented the Authors on the effort they expended to collect information on Skeena sockeye. The method for adjusting the PR calculations to account for differences in littoral productivity and competition among species seemed legitimate based on first principles. This reviewer expressed concern about the estimation of stock-specific exploitation rates because it is not clear that the stock-specific run timing curves are based on seasonal trends of total abundance.

Stock status

Aggregate returns have steadily increased since enhancement began in the early 1970s. Returns in the 1990s have ranged between 6.9 million in 1996 to a low of 0.91 million in 1998. Very strong returns were seen in 2000 and 2001 but they declined to 1.5 million in 2002 because of anticipated reduced production of age 4 and 5 sockeye.

For non-Babine sockeye, historical catch records are inadequate for return re-construction. Visual survey escapement data are variable and of unknown accuracy because of the wide variety of methods used. Fence counts are or have been available for some lake systems. The available data suggests that escapements to the non-Babine lakes have collectively declined and stabilized at lower levels, relative to Babine Lake, since the 1950s (Fig. 2.); however, escapement trends differ among lakes (Fig. 3). Escapements based on fence counts have identified lakes of concern. For example, Sustut escapements appear to have declined by 75% between 1992 and 2002. The variation in estimates of abundance trends among migration-timing groups are a consequence of increased exploitation of enhanced stocks. Escapements of early-timed populations have been the least affected whereas wild mid-timed populations have been the most affected. Escapement estimates of Late-timed populations have increased following implementation of more conservative management policies and continue to do so. Escapements of mid-timed populations average less than half of pre-enhancement levels.

Results

Results from the adjusted-PR model suggests that smolt biomasses are at less than 10% capacity for 2 of the 26 lakes, below 25% of capacity for six of the lakes, and

below 50% capacity for most of the lakes. The Authors noted that it is unclear whether the juvenile stock assessment of each lake is being accurately portrayed by the PR model and suggested that the results be considered preliminary. The analysis indicates the majority of non-Babine sockeye stocks are probably over-exploited by marine and in-river mixed-stock fishing. One reviewer suggested that sensitivity analysis could be done to identify which uncertainties are important.

Another reviewer was critical of the method for estimating the spawning escapement (Smax) that maximizes recruitment (Rmax) from the PR model. In cases where factors other than lake limitations control recruitment, Smax will be overestimated. The reviewer also pointed out that the PR model doesn't explicitly result in a reliable estimate of productivity. The reviewer suggested a two-stage process. First, categorize lakes into spawning and rearing limited systems. Use the PR model only on rearing limiting systems to estimate Rmax and use spawning limited systems to estimate egg-to-fry productivity. Insight into the range of productivity for Skeena sockeye could be based on stream-type life history strategies and/or based on other systems. Uncertainty in the relationship between sustainable exploitation rate and escapement could be expressed as a family of curves.

The Subcommittee noted that Bulkley and Maxan sockeye, in addition to other non-Babine stocks, represent a conservation concern but noted little assessment of these stocks in the Working Paper.

Subcommittee Conclusions

The Subcommittee agreed with the reviewers and concluded that the revised Working Paper should describe the assessment methods and the limitations. A subsequent paper could develop the simulation model and assess the sensitivity of the model to assumptions.

Subcommittee Recommendations

The Subcommittee recommended that the assessment be divided into two papers. The revised Working Paper should be a methods paper and identify limitations. A second paper should be prepared to describe the simulation model and assess the sensitivity to model assumptions

The Subcommittee recommended the paper be expanded to include an assessment of data for Maxan and Bulkley lakes given that they, along with other non-Babine systems, are identified as a conservation concern in the Working Paper.

The Subcommittee recommended that fishing plans recognize the depressed status of many non-Babine stocks and the need to preserve spawners.

The Subcommittee recommended habitat assessments and lake surveys for Bulkley and Maxan sockeye.

S2003-10: Models to adjust spawning escapement targets for Fraser River sockeye salmon (*Oncorhynchus nerka*) to compensate for the influence of environmental conditions on migration success

J.S. Macdonald, I.C. Guthrie, and D.A. Patterson **Accepted with Revisions**

Subcommittee Discussion

Data and methods

The goal of the paper was to explain the discrepancy between annual lower-river (Mission) and upstream spawning escapement estimates as a consequence of in-river environmental conditions and to provide an environmental management adjustment (EMA) to increase the likelihood that spawning escapement targets are achieved. Estimates of upriver escapement and run-timing for Fraser River sockeye were from hydroacoustic monitoring at Mission which has been done since 1977. Estimates for Early Stuart sockeye for 1977, 1980, 1982, 1984 and 1986 were excluded because, in anticipation of low abundance, hydroacoustic monitoring did not take place. Late-run estimates for 1977, 1979-95, 1987-89 and 1991-93 were also excluded because late-run fish occurred at low abundance or estimates were biased by very high abundance of co-migrating pink salmon. Spawning estimates are collectively available from the International Pacific Salmon Commission (PSC) and DFO from 1977 to the present. Estimates of escapements at Mission, and First Nations and recreational catches, were assigned to one of the four run-timing groups based on estimates of stock composition provided by the PSC. Lower Fraser River daily discharge has been measured at Qualark Creek since 1993. The high correlation of discharge measurements at Qualark with measurements made at Hope allowed extension of the time series to as far back as 1912. Daily mean water temperatures, also measured at Qualark Creek, were augmented with data collected at Hell's Gate since 1941 and with data from other locations. The time period used for discharge and temperature data for a given year was from 15 days before to 3 days after the 50% migration date at Hell's Gate. This was a consequence of the river condition models that provided the discharge and temperature forecasts, and the consideration of providing a timely EMA to Managers. Temperature and discharge variables were described as the means for the 19-day period and the number of days fish would have been exposed to temperatures and discharges above arbitrary thresholds during the 19-day period. The Authors noted that the discrepancy between lower-river and upstream counts included error in the catch and escapement estimates, as well as mortality which would be a consequence of river conditions. One reviewer thought it was unclear if years of low discharge were considered. In addition, the reviewer suggested that an analysis over years for an example stock be presented. The other reviewer suggested that the steps in model implementation from initially estimating the 50% date through to the in-season application of the EMA should be described for clarity. This would also show the temporal structure of the variables. Analysis focused on explaining the variation in the ratio of lower-river to upper-river escapement since 1977.

The explanatory variables used in the model to represent river conditions were the number of days above 17.7°C and mean discharge for Early Stuart sockeye, the number of days when discharge exceeded 7000 $m^3 \cdot s^{-1}$ and mean temperature for early Summer fish, the number of days above 18.8°C for Summer run sockeye, and the date of 50% migration for late-run sockeye. Principal component analysis was used to define the subset of variables which best described interannual variability in the ratios for each of the run-timing groups. Multiple regression analysis was used subsequently to develop models for predicting the ratio of lower-river to upper-river escapement.

The Authors indicated that qualitative forecasts are currently provided and that the Fraser River Panel will consider advice from the model for the upcoming fishing season as was the case in 2001 and 2002.

Results

The regressions developed for predicting the ratio of lower-river to upper-river escapement for each run-timing group are presented in Table 1. Application of the EMA reduced the discrepancy between lower-river and upper-river escapement estimates (Figs. 4 and 5) but the reduction was not quantified. The Subcommittee agreed with one reviewer suggesting that a retrospective leave-one-out analysis be done to evaluate the performance of the model. In addition, diagnostic plots of residuals should be provided and then transformed into arithmetic space for ease of interpretation. The Authors intend to examine propagation of error in the future. They felt that it was more crucial to forecast river conditions accurately than 50% date.

The EMA model can be used during in-season fisheries management to amend escapement targets. Potentially this will increase the ability to achieve spawning escapement both in years of favourable and unfavorable river conditions. Considering the capability of the discharge and temperature forecasting model, the first EMA can be provided for the Early Stuart, Early Summer and Summer runs seven days before the expected peak arrival at Hell's Gate, three days before the expected peak at Mission and about three days after the estimated peak abundance in Juan de Fuca Strait. There is no reliable method for predicting when late-run fish will begin their upriver migration. Therefore, forecasts can be made only if assuming there is no delay in the Strait of Georgia.

Subcommittee Conclusions

The Subcommittee accepted the paper with revisions and recognised that this is a work in progress.

The Subcommittee concluded that the model is not ready to be recommended for use by Management. It was questioned by the Subcommittee whether the formulation of

the regression model in the Working Paper was valid. Revisions of the paper need to ensure the model is statistically valid and account for all reasonable sources of error where possible. The authors should consider a response variable that is a predictor of the Mission target required to meet up-river spawning escapement targets given environmental uncertainty rather than the ratio of upper-river: lower-river escapement requirements. The Subcommittee concluded that a Decision Table would be useful to calculate the cost of errors in decision-making and that revisions to the Working Paper need to include a retrospective analysis to show how the model predicts past observations to assess its reliability and accuracy. The Subcommittee advised the authors to develop probability distributions of the prediction to help managers assess the risk of not meeting objectives.

Subcommittee Recommendations

The Subcommittee recommended accepting the paper with revisions.

The Subcommittee recommended the authors consider a reformulation of the model to predict the escapement target required at Mission to account for unfavorable environmental conditions.

The Subcommittee recommended that a retrospective analysis be included in the revisions and that uncertainty be expressed as probability distributions.

S2003-11: Inseason forecasting of North Coast coho salmon marine survival: A decision-analytic method and retrospective analysis

S. P. Cox, J. Sawada, W. de la Mare **Accepted with Revisions**

Subcommittee Discussion

Data and methods

The aim of the working paper was to develop and test an in-season early warning forecast of poor marine survival rate for North Coast coho. There were two data sources. The first was historical coded-wire tag releases and marine survival rates for Lachmach River, Toboggan Creek, and Babine River indicator streams. The second dataset was upper Skeena River Coho CWT recoveries, and catch and effort data for the boundary area troll fisheries; these were provided by the Alaska Department of Fish and Game. A simple removal model was developed to predict abundance and catch for each year and a week of fishing in the boundary troll area given the number of CWT's initially released, a marine survival rate for each stock and return year, and troll fishing effort for each week and year. One reviewer felt that the methods were sound but that the decision analysis requires further development. It was unclear to the reviewer how the cost functions could have contributed to the decision-making through retrospective analysis. The reviewer suggested that it would be helpful if the Authors provided a table for each stock which would show the

two decisions and their costs each year, retrospectively. The other reviewer was very complimentary and described the work as a "thoroughly modern approach to a classical fisheries problem".

Results

The estimation procedure performed reasonably well and predicted weekly catches especially during low abundance years when reliable forecasts are needed. The stock- and week-specific catchability parameters for the three stocks considered in the Working Paper showed a pattern which would be expected given the timing of their migration through the area of the boundary troll fishery. Estimated marine survival rates corresponded reasonably well to the observed marine survival rates for all stocks (Fig. 6). Concern was expressed about marine survival for the Lachmach stock being consistently under-estimated by approximately 5% over 1996-99. A reviewer suggested that this might be due to a change in smolt trapping and tag applications which could have affected marine survival rate estimates, or suggested that the tagged smolts were not a random sample of the smolt run. The in-season forecasts of marine survival were stable by the third week of the boundary troll fishery and were within 20 percent of the actual marine survival rates in many cases. The estimation scheme shows a strong degree of certainty that marine survival rates were low in years when an early warning was required. The Bayesian decision analysis detected all seven stock/year combinations for which marine survival rates were less in the critical survival values; these critical values were 50% of the mean marine survival rate for each stock over 1988-99. Six of the seven correct warnings were apparent based on the first week of troll fishing. In the exceptional year, it was relatively clear that the cost functions were conflicting by the second week, which would warrant a precautionary approach. The Bayesian analysis provided only one false warning, which was for Toboggan Creek in 1993. The Subcommittee noted that this method requires information on historic and in-season CWT fishing effort and past observations of marine survival.

The estimation algorithm appears to provide an early warning of poor survival, six weeks in advance of fishing in Canadian waters. The procedure also forecasts exploitation rates in Alaskan fisheries. Therefore, Canadian Managers could adjust exploitation in-season to protect against overfishing.

Subcommittee Conclusions

The Subcommittee considered the method a powerful tool for forecasting low marine survival of North Coast coho. It could also be used to determine tagging rates required to provide information of adequate certainty for subsequent forecasting. The Subcommittee complimented the Authors on the excellent work. In addition, the Subcommittee noted that decision-analytic approach requires consultation with user groups to establish the cost of errors in decision-making.

Subcommittee Recommendations

The Subcommittee accepted the paper with revisions.

The Subcommittee recommended the application be used as a general approach to in-season prediction of poor marine survival rate.

S2003-12: Stock status of wild chum salmon returning to British Columbia's Central Coast and Johnstone and Georgia Straits (excluding the Fraser River)

L. Godbout, J.R. Irvine, D. Bailey, P. Van Will, and C. McConnell **Accepted with Revisions**

Subcommittee Discussion

Data and Methods

This paper describes the status of chum salmon returning to the Central Coast (DFO Areas 7-13) and the Non Fraser Inner Study Area (ISA) (Areas 12-18, 28, and part of 29). Measures of stock status included stock size, analysis of spawning escapement and recruit/spawner (R/S) trends, and categories of stock size based on reference points. Records of total chum catches were extracted from DFO databases and wild catch was estimated using the proportion of unmarked fish as determined from commercial catch sampling. Spawner escapement estimates are derived from visual stream surveys. In enhanced streams, the proportion of wild fish was estimated as the proportion of unmarked fish. The recruit and spawner data was limited by inconsistent sampling over time and changes in methodology. A subset of streams that had escapement records for at least five years in each of the last four decades, was used in the analyses. A multiple regression method was used to provide estimates of escapement for years when data were missing. Finally, the estimates for the subset of streams were expanded to provide estimates for all streams in an area. These areas were the DFO Areas 7 through 13 and subdivisions of ISA into West (WJST) and East (EJST) Johnstone Strait, Northwest (NWGS), Northeast (NESG), Southwest (SWGS) and Southeast (SEGS) Georgia Strait. Trends were described for the complete time series and for the last three generations by fitting a simple least squares regression line to escapement and R/S data which had been smoothed by calculating 4-year running averages. Reference Points were defined in the context of S_{MSY}. When the number of spawners S was less than 10% of S_{MSY}, the stock was in the red zone. The stock was in the amber zone when S exceeded 10% S_{MSY} but was below S_{MSY}. The stock was in the green zone when S was greater than S_{MSY}. The Subcommittee asked that the 10% S_{MSY} benchmark be eliminated because it is overly conservative and recruits per spawner is likely biased high.

Both reviewers commended the Authors for assembling and analysing a large amount of data of varying quality. One reviewer felt that the stock groupings were arbitrary and not shown to be based on stock structure criteria used to define Designatable Units. The Subcommittee acknowledged that Designatable Units for chum have not yet been developed. There was no information provided on the accuracy or precision of escapement information. The statistical properties of these estimates should be presented so that the appropriateness of the analyses can be determined. The Authors will examine this using data from key indicator streams. In addition, the spawning ground age compositions could be biased and the source of samples needs to be identified. The Authors suggested that using the median minimizes bias, although the potential for bias was acknowledged. The sources of the data need to be identified more specifically. A reviewer felt that the authors developed useful benchmarks for assessing stock status. This reviewer was concerned that data used to develop the stock-specific benchmarks may be biased because estimates of wild catch and escapement were made by subtracting the estimated enhanced component. The Subcommittee agreed with one Reviewer and concluded that potential biases in the data, including confounding of trends by enhanced fish, and methodology be addressed more comprehensively. Using benchmarks based on 4-year running averages of escapement may be overly conservative and therefore less precautionary. A less conservative benchmark should be considered. One Reviewer noted that the final model used to complete missing data does not include a term related to geographic location. The Authors tested the effect of "North" and "South" designations and found no effects. The Subcommittee asked the Authors to provide a table showing that in fact there is no effect of area in the equation used to estimate missing escapement data.

Stock Status

There were 166 streams (69 Central Coast, 97 ISA) in the dataset. Tables 2 and 3 summarize the stock status information for the 1953-2000 time series and the last 3 generations (15 years) respectively. Areas 7 and 8 were grouped. These areas had the highest median R/S of the stocks considered and the fewest number of years when R/S was less than one. Escapements exceeded S_{MSY} in 25 and 15 of 50 years respectively which was comparable to other areas. There was no trend in abundance; however, this appeared to be due to increases in some streams offsetting declines in others. Over the last three generations, there has been an increase in escapement, and a reduction in exploitation. Areas 9 and 10 escapements did not vary over the complete time series. Of the Central Coast stocks, these had the greatest number of years when spawning escapement was at least S_{MSY}. Over the last three generations, escapements have increased in Area 9 but have declined in Area 10. Exploitation rates have declined. R/S for Area 10 has been below one since about the 1988 brood year. Area 11 chum had the lowest R/S and showed the greatest number of years (18/45) when recruitment was below replacement. There has been no trend in escapement over the last three generations. Median escapement was below that for the complete time series. WJST escapements have declined recently. EJST is the only stock with a large

aggregate escapement which has declined over time. The decline has continued over the last three generations. Fifteen of the 17 streams showed a decline in escapement that exceeded 5% per year. R/S was 1.13 compared to the median of 1.62. NWGS chum showed no trend in escapement over the complete time series; escapements appear to have increased over the last three generations. Escapement to SWGS, NEGS, and SEGS stocks has increased over the complete time series. Escapements for SWGS chum have declined recently with most streams showing declines exceeding 5% per year of the last three generations. Escapements to SWGS and NEGS stocks have shown no trend recently. Recent median escapements for all three areas exceed the time series medians. Exploitation rates have not changed. The Subcommittee asked that the escapement trends be re-analysed using the P_{max} method and the results compared with the escapement trends. It also noted that recent declining trends are exponential because the trend lines are plotted in log scale. Finally, the Subcommittee concluded that R/S relationships are suspect in some instances and that escapement trends provide sufficient information to assess stock status. The escapement data are indices and therefore adequate.

The Authors concluded that none of stocks appear to be threatened with extinction. They recommended that additional work be undertaken to explain the declining escapements for EJST chum. Both Reviewers stated that the conclusions would be useful to Managers. Although not discussed in the Working Paper, the Subcommittee discussed the implications of Summer and Fall chum runs. The Subcommittee thought it would be worthwhile to determine how best to identify these different timing groups from the perspective of diversity. Summer and Fall chum may have different productivity levels.

Subcommittee Conclusions

The Subcommittee accepted paper with revisions. It complimented the Authors on the effort expended to prepare the paper. The Subcommittee concluded that due to data quality issues, the conclusions on stock status are suspect. The Subcommittee noted the variation in escapement coverage over time is problematic and that the stock-recruitment analysis suffers because catch-at-age sampling is insufficient to estimate returns by brood-year. The Subcommittee agreed that the comparison of R/S ratios among areas and the inference that some areas are less productive than others is flawed because of inadequate catch sampling. The interpretation of these analyses for management need to be interpreted with extreme caution. The Subcommittee concluded that stock status should be described based on escapement trends only because of limitations in R/S data. A more thorough simulation analysis is required before productivity rates and S_{MSY} can be considered.

Subcommittee Recommendations

The Subcommittee accepted the paper with revisions.

The Subcommittee recommended a more thorough investigation of data to estimate productivity capacity of Central Coast chum.

The Subcommittee recommended studies to calibrate escapement indices to catch and abundance.

The Subcommittee recommended a comparison of the "summation" method to derive escapement indices presented in the paper with a method that weights each component system in an area equally (i.e. the Pmax method).

S2003-13: Review of 2002 chinook returns to the West Coast Vancouver Island, Forecast of the 2003 return to the Stamp River/Robertson Creek Hatchery indicator stock, and outlook for other WCVI Chinook stocks

A. Tompkins, W. Luedke, J. Till, S. Taylor, and D. Lewis **Accepted with Revisions**

Subcommittee Discussion

Data, forecasting methods and forecast performance

The Subcommittee noted that the paper used data sources and methods that have been previously reviewed and accepted by PSARC. Two forms of a sibling regression model are used to forecast total production-at-age for a given brood year for the Stamp River/Robertson Creek Hatchery indicator stock. The Subcommittee acknowledged that the sibling regression models result in forecasts that are amongst the most reliable in the Region. The mean absolute percent error over all years is 22%. Returns for natural spawning populations are forecast using two methods. The first is the relative change predicted for the Stamp River/Robertson Creek Hatchery indicator stock. The second is based on output from the coastwide Chinook Technical Committee model. The Authors noted that, unlike the 2001 surveys of natural stock indicators, the 2002 surveys were considered to be more accurate because of favourable survey conditions. The Subcommittee noted that populations in Clayoquot and Kyuquot Sound show a decline in abundance that is not apparent in other areas. The Subcommittee was concerned about the effects of data quality on apparent wild stock trends. The Authors suggested that trends were valid and that effects of factors such survey life estimates used in area-under-the-curve estimation methods cannot explain differences in escapement estimates among areas. The Subcommittee asked that retrospective analyses of forecasts for wild stocks be presented in the revision.

2002 Stock status

The estimated terminal return of chinook to the Stamp River/Robertson Creek Hatchery (RCH) indicator stock was 80,900 (age 3 and older), plus 2,400 Age-2 male (jacks) chinook. The return represented a two-fold increase from the 2001 return which was a 4-fold increase from 2000. Potential egg deposition met the

escapement requirements on the Stamp River, and was estimated to be 30 million. Returns to the Pacific Salmon Commission (PSC) indicator streams were variable. They increased by about 50% for northwest coast Vancouver Island stocks; increases in female returns were generally greater. Populations in Clayoquot Sound and two of the three streams in Kyuquot Sound showed declines in return abundance. The Subcommittee noted that all WCVI fish have the same life history type and DNA results suggest one Designatable Unit. The declines for these populations are a productivity issue because of impacts to local users.

The 2003 forecast

The forecast return for Stamp Falls/Robertson Creek Hatchery chinook to the terminal area of Barkley Sound is 86,000 fish (Table 4), similar to the 2002 return. Unlike recent years, all age-classes of adults will be represented, including the age-5 component which is mostly female. The number of females predicted in the terminal run is 46,000 fish which would contribute a potential deposition of 210 million eggs, four times the current egg deposition goal.

Returns to the naturally spawning populations are forecast to be 5-10% greater than those observed in 2002. Based on the indicator stock, the return is forecast to be 53% female. Consequently, egg deposition should improve. However, some of these populations (Clayoquot, Kyuquot) are expected to have fewer than 100 females. Consequently, a cautious approach to fishing should continue with special consideration for wild chinook stocks in Clayoquot Sound.

Subcommittee Conclusions

The Subcommittee accepted the paper with revisions. Revisions should include a retrospective analysis of the forecast performance and probability distributions of forecasts. The Subcommittee agreed that there are potential data quality issues in some WCVI chinook systems. In particular, survey conditions in Megin River are poor and the estimates for the last two years are questionable. The Subcommittee noted that escapement declines in Clayoquot and Kyuquot sounds are inconsistent with the trends in other areas where escapements have recently increased. The Subcommittee was concerned about the low levels of spawners in some systems (<100 fish) and implications for SARA. The Subcommittee noted that WCVI chinook are likely to be classified as the one Designatable Unit because the populations have the same life history type, similar run timing distributions, and DNA characteristics. The Subcommittee is concerned, however, because escapement declines of individual systems affect local fishing communities.

The Subcommittee agreed that current management actions to reduce mortality are appropriate. Continued cautious management is required such as restrictions on ocean exploitation rates to protect older fish from areas with declining escapement trends.

Subcommittee Recommendations

The Subcommittee recommended that the 2003 forecasts be accepted.

The Subcommittee recommended that forecasts be presented as probability distributions and that a retrospective analysis be done to evaluate forecast performance.

The Subcommittee recommended that the reason for the inconsistency between escapement trends for Clayoquot and Kyuquot chinook stocks compared to other WCVI stocks be investigated. If the trends are real, then research should be conducted to determine what is affecting abundance.

APPENDIX 1: Working Paper Summaries

S2003-07: Trends in abundance for Northern BC chum salmon

B. Spilsted

This Working Paper documents chum salmon escapement trends and provides 2003 escapement forecasts of northern coastal British Columbia (Statistical Areas 1 to 6).

Long-term escapement trends

The Q.C.I. index stream aggregate shows generally stable escapement for the past 30 years. Area 1 escapements are highly variable, with no apparent trend. Area 2 West streams show a stable pattern of chum escapement, similar to the Q.C.I. aggregate. The 2 East index stream aggregate shows periods of both increasing and decreasing abundance. The overall trend is not clear. It is recommended that the current conservative management approach of terminal net fisheries directed on identified surplus escapement should continue.

North Coast chum streams in Areas 3, 5 and 6 show a long-term decline over the years 1950 to 2002. Area 4 escapements are highly variable, with no apparent trend. Chum stocks in Areas 3 to 6 need to be rebuilt.

2003 Escapement forecast

A summary of chum salmon escapement forecasts for index stream aggregate by Statistical Area and their characterization relative to a long-term mean and Fisheries and Oceans Canada Fisheries Management staff escapement goals is presented in the following Table:

Stat. Area	Stock	Escapement Goal	Mean Esc. (1950-2002)	2003 Forecast[1]	50% CI	Characterization of Status
1	Index	70,000	43,000	13,000	0 - 20,000	Below Esc. Goal, variable without trend
2E	Index	260,000	130,000	72,000	32,000 - 99,000	Below Esc. Goal, variable with slight downward trend
2W	Index	170,000	90,000	83,000	24,000 - 89,000	Below Esc. Goal, variable without trend
3	Index	89,000	38,000	22,000	11,000 - 29,000	Depressed, long term decline, anticipated 2003 returns well below Esc. Goal and Mean Esc.
4	Index	52,000	14,000	5,400	570 - 8,000	Highly variable, no observable trend
5	Index	29,000	14,000	2,600	790 - 3,700	Depressed, long term decline, anticipated 2003 returns well below Esc. Goal and Mean Esc.
6	Index	320,000	130,000	80,000	27,000 - 110,000	Depressed, long term decline, anticipated 2003 returns well below Esc. Goal and Mean Esc.

[1]2003 forecast using 5YRA model.

S2003-08: Assembly of standardized estimates of juvenile and adult sockeye salmon (*Onchorynchus nerka*) abundance associated with the 1976-2001 brood years in Henderson Lake and Clemens Creek, British Columbia

K. Hyatt, D.P. Rankin, P.J. Tschaplinski, and I. Miki

In this paper the authors review the development of acoustic and trawl survey (ATS) based estimates of juvenile sockeye and standardized spawner abundance estimates for adult sockeye at Henderson Lake, B.C. over the 20- 25 year interval (1977-2001) during which we have conducted surveys there. Henderson Lake is the third largest sockeye nursery lake contributing to the Barkley Sound sockeye fishery. The lake was treated with inorganic fertilizer between the Brood Years 1975 and 1998. A private hatchery has been incubating sockeye salmon eggs taken from the spawning escapement and out planting the fry into lake since Brood Year 1993. ATS based estimates have been adjusted for species and size-related vulnerability to produce a set of standardized estimates of smolt output. The impact of limnetic fish density and inorganic fertilizer treatments on limnetic fish production and sockeye smolt size are examined. Standarized escapement estimates are produced based on "Stream walks" and Petersen Mark Recaptures (PMR). Potential Egg Depositions are estimated from escapement numbers and Egg to "Fall Fry" survivals are calculated using standarized ATS based estimates.

S2003-09: Stock status and lake based production relationships for wild Skeena River sockeye salmon

S. Cox-Rogers

This paper outlines stock status for wild Skeena River sockeye salmon based on freshwater production in the nursery lakes. We also develop a simulation model from these data for assessing fishery impacts. Harvest and exploitation rates for Skeena sockeye are currently estimated for the aggregate stock alone using run-reconstructed catch and escapement data and an in-season management model. The aggregate stock is dominated by enhanced sockeye returning to the Babine Lake spawning channels at Pinkut and Fulton Creeks. At least 90% of Skeena sockeye now originate from the Babine Lake system compared with less than 80% prior to 1970. In addition to Babine Lake, wild sockeye return to approximately 28 other nursery lakes throughout the Skeena River drainage.

In recent years, concern for wild Skeena River sockeye stocks has lead DFO to begin evaluating their stock status, production dynamics, and exploitation in fisheries targeting the more productive enhanced Babine Lake component. Catch and escapement data for wild Skeena sockeye are of variable quality and cannot be used to develop adult production relationships or to assess stock status beyond general impressions. An alternative approach is to estimate sockeye rearing capacity of the

nursery lakes from limnological data and to determine current stock status from juvenile sockeye acoustic and trawl surveys.

Past studies reported limnological and juvenile sockeye data for 10 Skeena nursery lakes. Using these data they produced estimates of the maximum number of juveniles (smolts) each lake could produce and the number of adult spawners required to produce these smolts. The estimates were generated with a habitat-based photosynthetic rate (PR). Past studies showed most Skeena nursery lakes to be oligotrophic, fry-recruitment limited, and producing sockeye below potential production. Besides recruitment limitation, a wide range of other factors were identified as limiting sockeye production from non-Babine lakes ranging from glacial turbidity (Kitsumkalum Lake) to extremely low nutrient levels (Morice Lake) to potential spawning ground limitation.

In this paper, we provide background to the PR model and update stock status for Skeena Lakes based on PR model predictions and available adult escapement data. We also present a method for determining stock and recruitment relationships between smolt biomass and spawning escapement using PR-model output. We then use the relationships in a simulation model that can be used for predicting future escapements to Skeena nursery lakes under different fishing regimes. The simulation model generates probabilistic statements about future trends in spawning stock size relative to possible escapement "reference point" guidelines and established conservation (COSEWIC) thresholds.

S2003-10: Models to adjust spawning escapement targets for Fraser River sockeye salmon (*Oncorhynchus nerka*) to compensate for the influence of environmental conditions on migration success

J.S. Macdonald, I.C. Guthrie, and D.A. Patterson

Estimates of sockeye salmon escapement as they enter the Fraser River tend to exceed post-season estimates made on the spawning grounds for early runs of Fraser River sockeye salmon. The magnitude of these differences can be very large in years when difficult migration conditions such as high discharges or temperatures are encountered, and have been detected in relation to mid summer runs as well. An apparent en route mortality as high as 95% has also been detected in Late-run stocks in recent years, but in association with abnormally early entry into the river rather than extreme migration conditions. Differences between the in-season estimates of escapement, that are used immediately to drive management decisions, and the post-season estimates of escapement on the spawning grounds create severe difficulties for fisheries management by jeopardizing both catch allocation goals and spawning escapement targets. Unachieved escapement targets can reduce stock productivity and delay or reverse stock re-building initiatives.

In this paper we review the historic differences between estimates and investigate their relationship with the river temperature and discharge conditions faced by Fraser

sockeye to produce management-oriented predictive models. Model output is used to produce an "environmental management adjustment" (EMA) that represents the anticipated difference between lower-river and upriver spawning escapement estimates due to a combination of in-river mortality and unspecified error in various abundance estimates. It provides a means to adjust in-season spawning escapement targets. Our analysis shows that models that predict the difference between in-season and post-season abundance estimates based on environmental conditions and, for Late-run stocks, migration timing can substantially improve in-season expectations of the numbers of fish that will eventually be estimated on the spawning grounds. We describe the use of forecasted river discharges and temperatures to assist in the implementation of these models as in-season management tools. These models also provide insight into the physiological and ecological adaptations developed by Fraser River sockeye to deal with a variable migratory environment.

S2003-11: Inseason forecasting of North Coast coho salmon marine survival: A decision-analytic method and retrospective analysis

S.P. Cox, J. Sawada, and W. de la Mare

This paper develops an estimation algorithm that is intended to provide early warnings of poor marine survival conditions for Canadian North Coast coho stocks. The modelling approach attempts to partition weekly variation in observed coded-wire tagged (CWT) coho catches in boundary troll fisheries into components that depend upon total CWT coho smolts released, troll fishing effort, and marine survival rates. Uncertainty in marine survival rate forecasts is addressed via a Bayesian decision analytic framework, which accounts for overfishing risk. Statistical approaches, forecast accuracy, and forecast biases were tested using simulated data.

Retrospective marine survival forecasts compared favorably with actual marine survival estimates obtained from post-season catch and escapement estimates and with previous assessments that attempted to forecast marine survival. The algorithm provided accurate warnings of poor marine survival conditions in all years for which such warnings were required. One false warning was issued from 19 possible cases, or a 5\% Type I error rate.

The marine survival forecasting procedure provides early warnings of poor marine survival up to 6 weeks in advance of the Canadian coho fishery opening. Therefore, it allows sufficient time for Canadian coho fishery managers to react to adverse marine survival conditions.

S2003-12: Stock status of wild chum salmon returning to British Columbia's Central Coast and Johnstone and Georgia Straits (excluding the Fraser River)

L. Godbout, J.R. Irvine, D. Bailey, P. VanWill, and C. McConnell

The overall goal of the authors was to assess the status of the following six stocks of wild chum salmon from central and southern British Columbia and to describe how their status varied temporally:

- Four northern stocks that return to DFO Statistical Areas 7, 8, 9, and 10
- A fifth stock comprised of fish returning to Area 11 (Seymour Inlet).
- A sixth stock comprised of fish returning to Areas 12 to 28 but excluding fish from the Fraser River watershed.

To assess status we (the authors') estimated stock sizes, analysed trends in several abundance indicators, and compared stock sizes with reference points. We calculated two reference points based on the number of spawners at MSY (S_{MSY}) that defined three zones (red, amber, and green). In the green zone, spawner abundance was at least sufficient to produce MSY and hence the stock did not appear to be threatened. In the amber and red zones, spawner abundance was below S_{MSY} and below 10% S_{MSY} respectively.

Chum salmon in Areas 7 and 8 were generally in the green zone and recruits/spawner (R/S) almost always exceeded replacement levels. There are no apparent management concerns with these fish. However, we have some concerns for chum returning to Areas 9-11, and the North East region in Johnstone Strait.

Although escapements to Area 9 did not exhibit any trend, populations were in the amber zone 30 years out of 50, raising the possibility of over-exploitation early in the time series. Escapements in Area 10 recently declined, and in one recent year the population was in the red zone. Declines appeared to be a consequence of reduced R/S. Current exploitation of this stock is extremely limited. Although escapements in Area 11 (and elsewhere) were highly variable, in Area 11 they nevertheless declined over the time series. Chum in this area had the lowest R/S and presumably were susceptible to over-fishing. Exploitations were generally low, except for a period in the 1980's when this stock was usually in the amber zone.

There was significant variability within the sixth, southern southern stock. Populations on both sides of Johnstone Strait declined recently. The decline of the Eastern population was the largest, recent escapements were approximately one-half those estimated early in the time series. Interestingly, chum in Northwest Georgia Strait showed evidence of a significant increase during the last three generations, and were often in the amber and green zones. This increase may be related to changing fishery practices on enhanced chum returning to this area. Chum returning to the Northeast, Southwest and Southeast of Georgia Strait had similar patterns. These three populations increased during our time series, and in the last generations were mostly in the green zone.

S2002-13: Review of 2002 chinook returns to the west coast Vancouver Island, forecast of the 2003 returns to the Stamp River/ Robertson Creek hatchery indicator stock, and outlook for other WCVI chinook stocks

A. Tompkins, W. Luedke, J. Till, S. Taylor, and D. Lewis

The intensive assessments and resulting abundance forecasts of the Robertson Creek Hatchery (RCH) and Stamp River chinook are undertaken annually for management of ocean and terminal fisheries, and as an indicator of the expected returns to the naturally spawning chinook populations along the west coast of Vancouver Island (WCVI). The status of the natural spawning stock and forecast returns for 2003 are presented in this paper.

For 2003, the forecast indicates continued improvement in returns of most hatchery and natural spawning chinook populations along the WCVI. However, improvement was not evident in two areas, including the natural spawning populations in Clayoquot (Area 24) and Kyuquot (Area 26) sounds. Consequently, a cautious approach to fisheries management is suggested.

APPENDIX 2: PSARC Salmon Subcommittee Meeting Agenda MAY 13 -15, 2003

PSARC Salmon Subcommittee Meeting
Re: Stock Assessments
May 13-15, 2003
Seminar Room, PBS, Nanaimo

Tuesday May 13, 9:00

9:00 – 9:30 Introduction and procedures
9:30 – 10:00 Review of 2002 Chinook returns to the WCVI, forecast of the 2003 return to Stamp River/Robertson Creek Hatchery indicator stock, and outlook for other WCVI chinook stocks
10:00 – 10:30 Break
10:30 – 11:30 WCVI chinook forecast cont.
11:30 – 12:00 Review rapporteur report
12:00 – 13:00 Lunch
13:00 – 14:30 Inseason forecasting of North Coast coho salmon marine survival: A decision-analytic method and retrospective analysis
14:30 – 15:00 Break
15:00 – 15:30 North Coast coho inseason forecasting cont.
15:30 – 16:00 Review rapporteur report

Wednesday May 14, 8:30

8:30 –10:00 Stock status of wild chum salmon returning to BCs Central Coast and Johnstone and Georgia Straits (excluding the Fraser River)
10:00 – 10:15 Break
10:15 – 10:45 Central chum status cont.
10:45 – 11:00 Review rapporteur report
11:00 – 12:00 Trends in abundance of Northern BC chum salmon
12:00 – 13:00 Lunch
13:00 – 14:00 Northern chum abundance cont.
14:00 – 14:15 Review rapporteur report
14:15 – 14:30 Break
14:30 – 16:30 Models to adjust spawning escapement targets for Fraser sockeye salmon (*Oncorhynchus nerka)* to compensate for the influence of environmental conditions on migration success
16:30 – 16:45 Review rapporteur report

Thursday May 15, 8:30

8:30 –10:00 Stock status and lake based production relationships for wild Skeena River sockeye salmon
10:00 – 10:15 Break
10:15 – 10:45 Wild Skeena sockeye status
10:45 – 11:00 Review rapporteur report
11:00 – 12:00 Assembly of standardized estimates of juvenile and adult sockeye salmon (*Oncorhynchus nerka)* abundance associated with the 1967-2001 brood years in Henderson Lake and Clemens Creek, BC
12:00 – 13:00 Lunch
13:00 – 14:00 Henderson sockeye status
14:00 – 14:15 Review rapporteur report
14:15 – Adjournment

APPENDIX 3: List of Attendees

Subcommittee Chair: Ron Tanasichuk
PSARC Chair: Al Cass

DFO Participants	Tues	Wed	Thurs	
* denotes Subcommittee Members				
Bailey, Richard*	x	x	x	
Brown, Gayle*		x	x	
Cass, Al*	x	x	x	
Cook, Roberta*	x	x	x	
Cox-Rogers, Steve*	x	x	x	
Curry, Gordon		x		
Davies, Shaun	x	x	x	
Fagan, Jen	x			
Godbout, Lyse			x	
Hepples, Jonathan*		x		
Holtby, Blair*	x	x		
Hyatt, Kim*			x	
Ionson, Bert*	x	x	x	
Irvine, Jim*	x	x	x	
Jantz, Les*		x	x	
Luedke, Wilf*	x		x	
McConnell, Carmen		x		
McNicol, Rick*	x	x	x	
Meerburg, Dave*	x	x	x	
Nagtegaal, Dick	x			
Parken, Chuck*	x	x	x	
Potyrala, Mark*	x	x	x	
Sawada, Joel	x	x	x	
Simpson, Kent*	x	x	x	
Spilsted, Brian	x	x	x	
Tanasichuk, Ron	x	x	x	
Thomas, Greg*	x	x		
VanWill, Pieter*		x	x	
Yockey, Cindy*	x	x	x	

External Participants:				Affiliation
Ginetz, Ron	x			BC Sport Fishing Association
Glendale, Fred		x	x	Kwakiutl Territories Fisheries Commission (KTFC)
Lane, Jim	x		x	Nuu Chah Nulth Tribal Council
LeBlond, Paul		x		Pacific Fisheries Resource Conservation Council (PFRCC)
Harling, Wayne	x			Sport Fishing Advisory Board (SFAB)

Hunt, Stanley	x	x	x	KTFC
Kristianson, Gerry	x	x		SFAB
Murphy, Marilyn	x			SFAB
Riddell, Brian	x	x	x	PFRCC
Rombough, Les	x	x	x	Pacific Salmon Harvesters Society
Shepert, Marcel	x	x	x	PFRCC
Webb, Lloyd	x	x	x	Fishing Vessel Owners' Assoc.
Observers:				
Blackbourn, David	x	x	x	Consultant
Scarfo, Kathy	x			Area G, Troll Association

Reviewers for the PSARC papers presented at this meeting are listed below, in alphabetical order. Their assistance is invaluable in making the PSARC process work.

Bailey, R.	Fisheries and Oceans
Brown, G.	Fisheries and Oceans
Brown, T.G.	Fisheries and Oceans
Fu, C.	Fisheries and Oceans
Holtby, B.	Fisheries and Oceans
Hop Wo, L.	Fisheries and Oceans
Johnston, T.	B.C. Ministry of Fisheries
McNicol, R.	Fisheries and Oceans
Parken, C.	Fisheries and Oceans
Simpson, K.	Fisheries and Oceans
Sweeting, R.	Fisheries and Oceans
Wood, C.	Fisheries and Oceans

Tables and Figures

Table 1. Final selection of the "best" regression models for each run-timing group, showing the predictor variables, parameter estimates and performance measures. (RMSE = root mean square error.)

Variables		Parameter Values			Model Fit		
β1	β2	α	β1	β2	Adj. R^2	Prob.	RMSE
Early Stuart							
#days T>=17.7°C	Mean Discharge (cms)	-1.2677	0.1171	2.81E-04	46.0%	0.0021	0.4534
Early Summer							
#days Q>=7000cms	Mean Temperature (°C)	-2.8384	0.1605	0.1756	53.3%	<0.0001	0.3521
#days Q>=7000cms	#days T>=17.7°C		0.1519	0.0290	*a*	<0.0001	0.3514
Summer							
#days T>=18.8°C		-0.1185	0.0235		26.0%	0.0054	0.2227
Mean Temperature (°C)		-2.3832	0.1329		21.1%	0.0122	0.2300
Late-Lates							
50% Mission Date		19.431	-0.0735		92.2%	<0.0001	0.3130

a Adjusted R^2 not directly comparable to results from models with intercept.

Table 2. Summary of important statistics based on the entire time series that were used to categorise stock status. Arrows indicate direction of trends (i.e. up or down), when they exist.

STOCK (Area)	ESCAPEMENT							RECRUITS/SPAWNER			Exploitation	
	Aggregate			% change/yr (number of streams)								
	Median Esc.	Yrs S≤ S_{MSY}	Linear Trend	≤-5	>-5 - <0	>0	Unclassified	Median R/S	Yrs R/S<1	Linear Trend	Median Expl.	Trend
7	195,161	25/50		3	19	6	9	2.43	4/41		0.54	↑↓
8	146,065	15/50		6	8	4	3	2.98	1/41		0.6	
9	27,325	30/50			5		3	2.16	7/41		0.36	↓to 0
10	18,925	24/50			1	1	1	1.85	13/41	↓	0.28	↓ to 0
11	28,742	19/50	↓		4	2	3	1.33	18/45		0.09	↓↑↓ to 0
WJST	44,917	23/49		2	1	2	1	1.51	12/44	↑	0.31	↓
EJST	157,128	18/49	↓	4	12	1	9	1.62	13/44	↓	0.31	↓
NWGS	24,853	19/49		3	6	1	4	1.77	14/44		0.31	↓
NEGS	112,933	19/49	↑	5	6	10	4	1.49	11/44		0.31	↓
SWGS	166,718	17/49	↑	5	2	3	1	1.66	10/44		0.31	↓
SEGS	116,069	16/49	↑		1	3	2	1.85	14/44	↓	0.31	↓

Table 3. Summary of important statistics based on the last three generations only that were used to categorise stock status. Arrows indicate direction of trends (i.e. up or down), when they exist.

STOCK (Area)	ESCAPEMENT							RECRUITS/SPAWNER			Exploitation	
	Aggregate			% change/yr (number of streams)								
	Median Esc.	Yrs S≤ SMSY	Linear Trend	≤- 5	>- 5 - < 0	>0	Unclas-sified	Median R/S	Yrs R/S<1	Linear Trend	Median Expl.	Trend
7	215,248	7/15	↑	5	2	15	15	1.82	2/15		0.37	↓
8	177,651	3/15	↑	2		10	9	2.58	0/15	↓	0.59	
9	17,449	9/15		3		2	3	1.68	2/15		0.24	↓to 0
10	17,935	7/15	↓	3				0.87	6/15	↓	0.06	↓to 0
11	19,708	8/15		5			4	1.06	5/15		0.08	↓to 0
WJST	80,287	5/15	↓		1	2	3	1.34	2/15	↓	0.28	
EJST	87,809	10/15	↓	15	1	1	9	1.13	4/15	↓	0.28	
NWGS	16,950	9/15	↑	1		11	2	4.17	1/15		0.28	
NEGS	133,578	1/15		10	1	2	12	1.46	3/15		0.28	
SWGS	215,852	3/15	↓	8			3	1.21	4/15		0.28	
SEGS	148,507	1/15		2		2	2	1.47	2/15		0.28	

Table 4. Summary of forecasted abundance and terminal run size of Stamp River chinook salmon with no Canadian fisheries. Terminal run after Canadian fisheries to be determined by managers in consultation with stakeholders.

	Pre-Fishery Abundance	Terminal Run with no Canadian Fisheries	Age composition
1. Model Prod 2 (Terminal vs Total Production)			
2000 brood	64231	10425	10%
1999 brood	113483	58993	57%
1998 brood	41327	33916	33%
Total	219,041	103,333	
2. Model Prod 3 (Total vs Total Production)			
2000 brood	22520	3655	6%
1999 brood	69881	36327	57%
1998 brood	28279	23207	37%
Total	120,680	63,189	
3. Average of Prod2, Prod3 (2000 brood based on Prod2 model only)			
2000 brood	43375	10425	12%
1999 brood	91682	47660	55%
1998 brood	34803	28561	33%
Total	169860	86,646	

Fig. 1. Annual peak counts of sockeye spawners in Clemens Creek, 1981-2001.

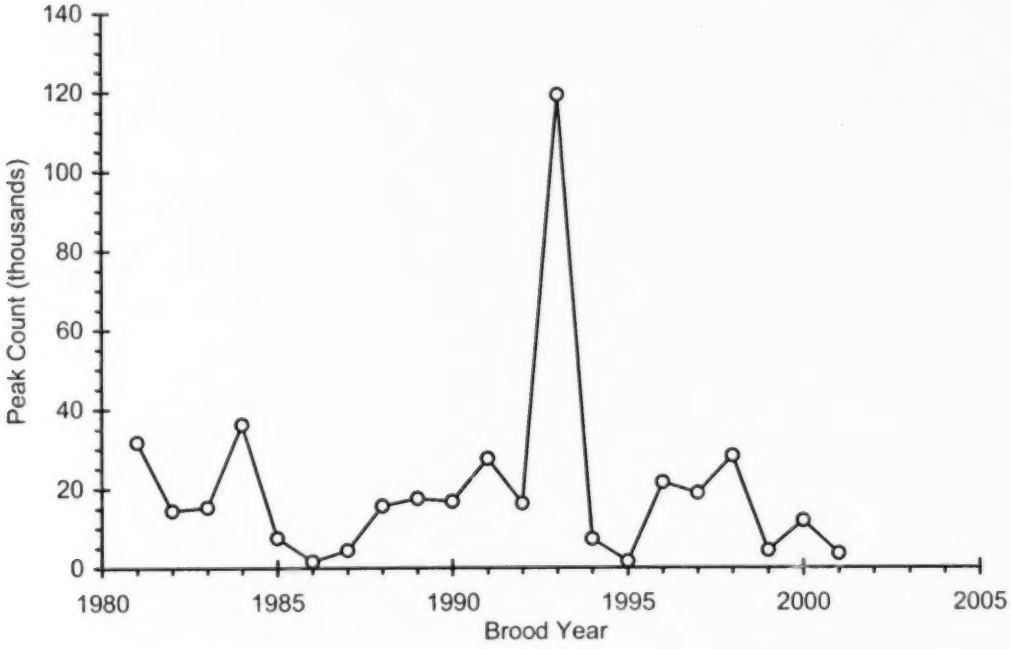

Fig. 2. Sockeye salmon counts through the Babine River counting fence at Babine Lake and estimated aggregate escapement for non-Babine nursery lakes, 1950-2002. The smoothed trend line is the LOWESS fit.

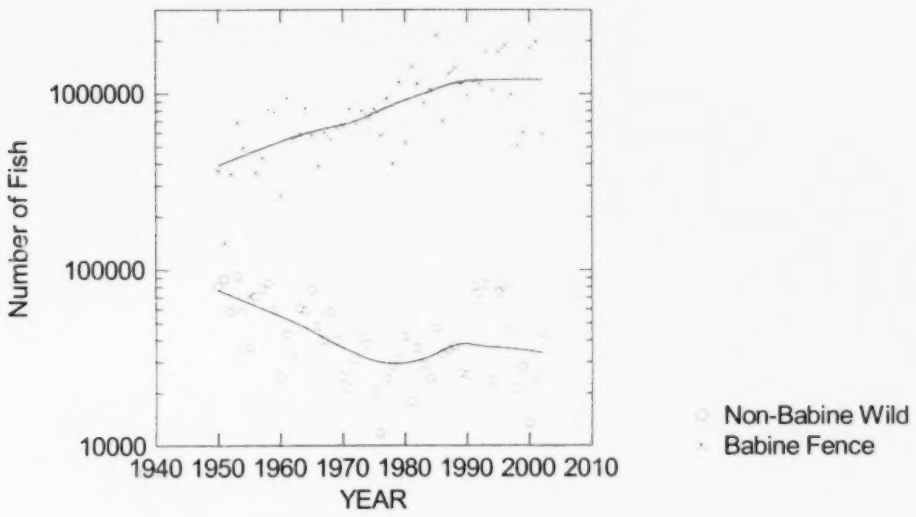

Fig. 3. Escapement records for non-Babine nursery lakes, 1950-2002. The smoothed trend line is the LOWESS fit.

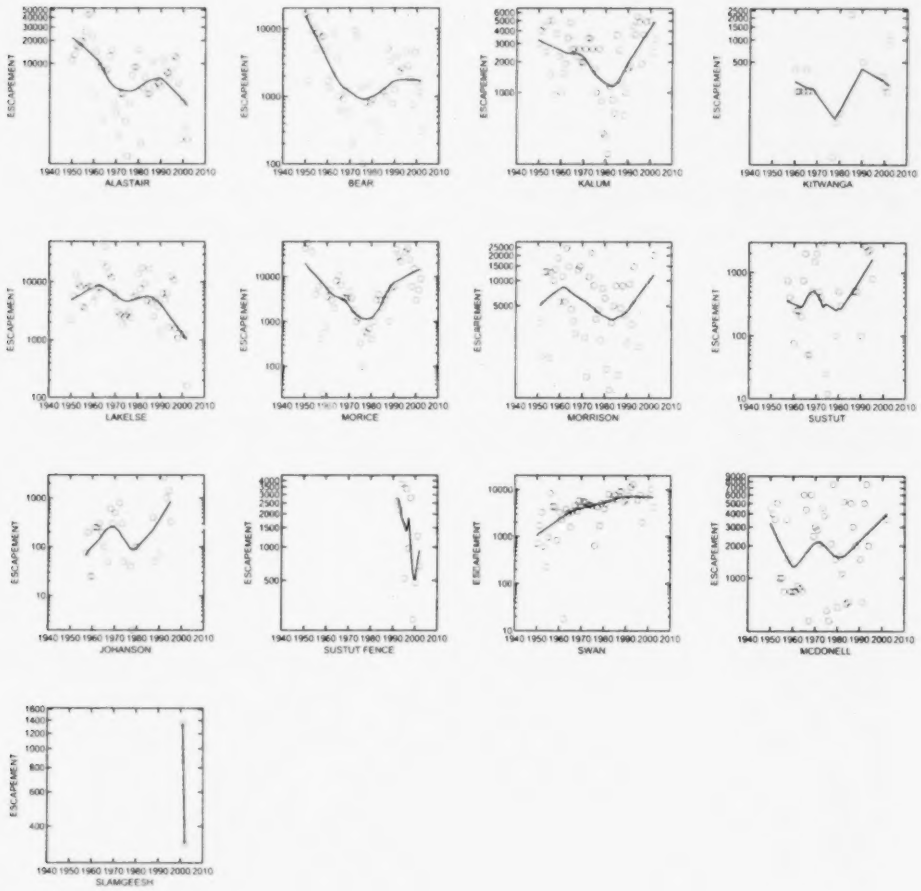

Fig. 4. Comparison of lower-river (in-season) and upriver (post-season) estimates of spawning escapement for each run-timing group, showing years of extreme temperature or discharge for early and summer stocks, and 50% migration date at Mission for the Late run (excluding Birkenhead).

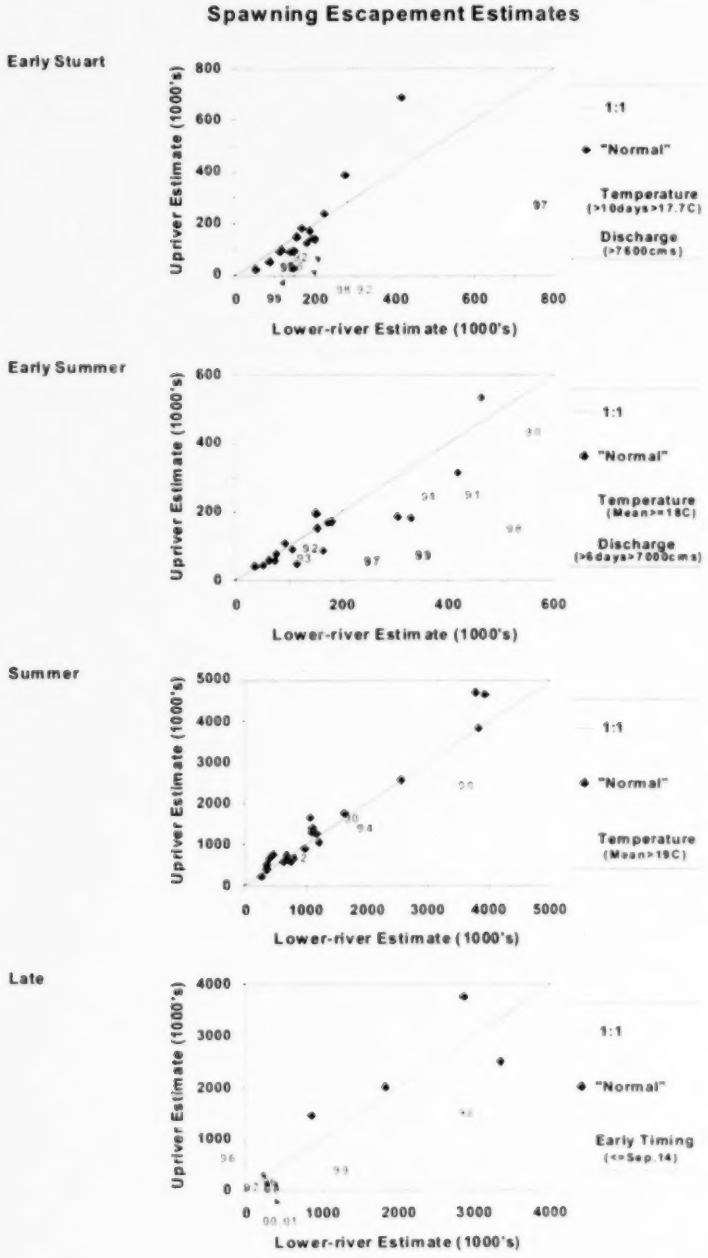

Fig. 5. Predicted versus actual lower-river spawning escapement estimates derived from the "best" environmental management adjustment models for each run-timing group showing years of extreme temperature or discharge for early and summer stocks, and 50% migration date at Mission for the Late run (excluding Birkenhead).

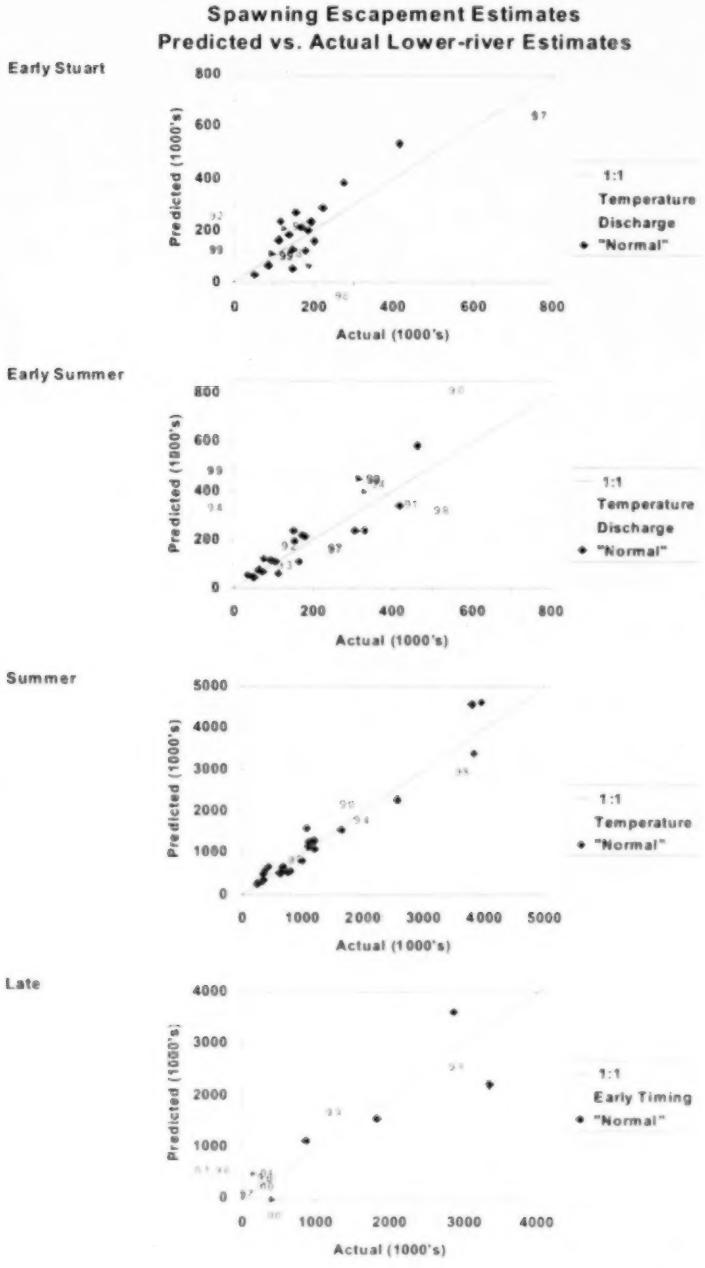

Fig. 6 Residual deviations between in-season and post-season marine survival rate estimates for Tobaggan Creek (circles), Lachmach River (squares), and Babine River (diamonds) coho.